Ink Jet Tools for Precision Fabrication

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Abstract

Purpose-built ink jet printheads are now recognized as useful tools in manufacturing where precision deposition is required. Piezoelectric drop-on-demand ink jet printheads offer the critical combination of high productivity, high reliability and jetting uniformity characteristics (drop volume consistency, velocity characteristics and jet straightness) for depositing a very wide range of materials dissolved or dispersed in organic or aqueous media. For example, ink jet printheads are key components in pilot production lines that manufacture RGB PLED displays for mobile phones. Even as ink jetting has gained a presence in display and electronics manufacturing, new opportunities are appearing that require smaller drops and increased productivity. Success with many of these new applications will require both process and fluid research and engineering.

This paper describes Dimatix's approach to facilitate the development of manufacturing processes for both rigid and flexible substrates and development of new functional fluids.

Introduction

Ink jets are successfully being used as precision micropumps in a wide variety of industrial applications. The past several years have seen increased reliance on piezo-based micropumps to develop new processes for manufacturing flat panel displays. These applications and many others take advantage of ink jet strengths.

1. Non-contact process
    a. Reduced contamination
    b. Wide variety of substrates
    c. Digital adjustment for substrate distortion
2. Micropump components may be designed to be non-contaminating
3. Process steps may be reduced by directly printing features
4. Additive process that avoids waste of expensive materials and may reduce environmental issues

On the other hand, challenges remain before ink jets can reach full potential:

1. Easy to use system
2. System reliability requires coordination of hardware, software, jetting fluid, ink jet print engine
3. High drop placement precision
4. Scalability of processes

Customer demands for increased performance within the precision micro-fluidic markets can be satisfied by designing piezoelectrically actuated ink jet micropumps based on single crystal silicon Micro-Electro-Mechanical (MEMS) manufacturing processes.

SX3: 128 Nozzle Micropump

Dimatix's SX3 micropump has been designed to meet the needs of a variety of manufacturing processes including those that a utilize flexible substrates. Market demand for improved drop placement capability, fluid jetability, and micropump longevity has driven the development of silicon nozzle technology for this ink jet printhead, which is a derivative of our SX-128.[1]

Figure 1 illustrates the SX3, showing a polymer cover to improve external robustness and the new MEMS-based nozzle plate.

Specifications for the SX3 are given in Table 1. The durable non-wetting coating is designed to improve jetting characteristics and to make maintenance easier.

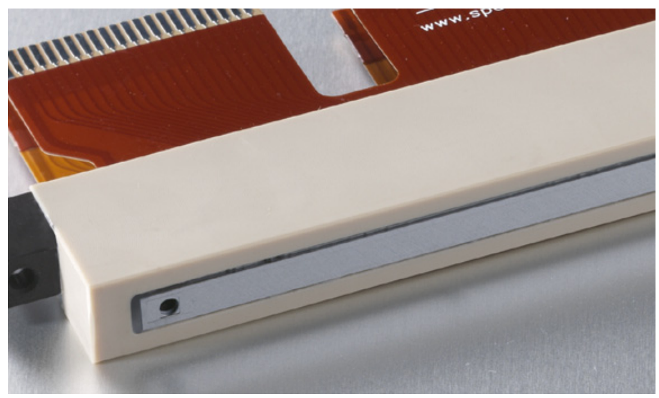

Figure 1. SX3 with Durable Non-Wetting Coating on Silicon Nozzle Plate

Table 1: SX3 Operational and Physical Parameters

Specifications	
# of Addressable Jets	128
Nozzle Spacing	508 microns [0.020"]
Drop Volume	12 Picoliters
Adjustment Range	10-12 Picoliters
Drop Volume Variation	< 2% w/ TDC electronics
Nominal Jet Velocity	8 m/sec
Spot Location (all sources)	+/- 10 microns @ 1mm
Compatibility	LEP/PEDOT/PPV, etc.
Drop Velocity Variation	+/- 5% without turning
Operating Frequency	Up to 10kHz to specification

MEMS-Based Material Deposition Technology and Micropumps

The major steps in Dimatix's fabrication process are the following:

1. Final wafer is fabricated from a three wafer stack-up, two silicon wafers and a PZT structure.
2. Dies are then separated from the wafer to produce deposition heads with the targeted amount of nozzles.

Other than the integration of the PZT into the wafer stack, all other processes are either IC-based or MEMS processes. Examples of these processes are metal sputtering, wafer grinding and chemical-mechanical polishing, as well as deep reactive ion etching (DRIE) and silicon fusion bonding. Photolithographic process is used to define the planar geometries. An example of the basic structure is shown in Figure 2.[2]

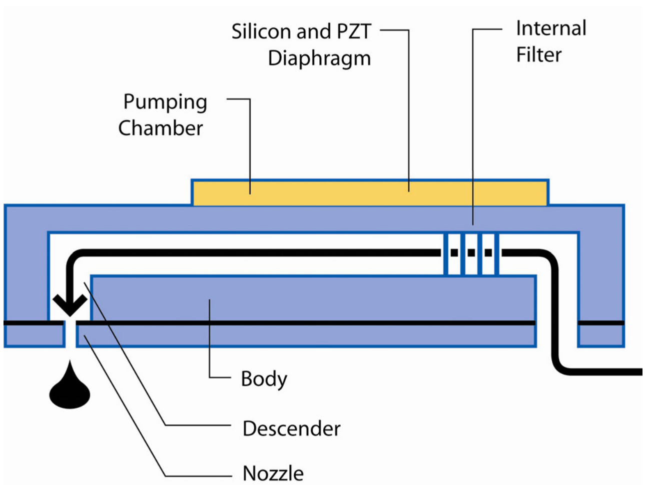

Figure 2. Schematic for new MEMS piezo ink jet

Silicon material, the base material for the MEMS processes, is a superior mechanical material with properties enabling a wide variety of deposition materials and inks. Dimatix has demonstrated superior resistance of the shaped piezo silicon to a wide variety of jetting formulations for aqueous inks, solvents and both highly acidic and basic fluids. In addition, the technology used to fuse the various layers of wafer material is also very resistant to chemical attack; a very common problem in many jetting systems used today. Finally and equally important is the fact that the outer surface is also made of silicon, which has been treated to provide a durable non-wetting exterior surface. This treatment allows frequent wiping and deposition of abrasive suspensions without damage.

Conclusion

New silicon nozzle technology can improve SX3 micropump performance for many precise manufacturing processes. The MEMS architecture, integrated with silicon processes, enables a highly flexible design of different nozzle diameters and droplet properties. This new architectural approach allows additional scaling of nozzle spacing, drop sizes as well as overall fluidic dimensions to be part of the product design, aimed towards specific applications.

References

1. Will Letendre and Amy Brady, "Advances in Piezoelectric Micropump Precision Deposition Using Silicon Nozzles," Imaging Science & Technology Non-Impact Printing 20 Conference, November 2004.
2. Chris Menzel, Andreas Bibl, and Paul Hoisington, "MEMS Solutions for Precision Micro-Fluidic Dispensing Applications," Imaging Science & Technology Non-Impact Printing 20 Conference, November 2004.

Author Biography

Dr. Creagh is currently Business Development Director in Dimatix's Materials Deposition Division, Santa Clara, California. Dimatix, Inc. designs and manufactures ink jet printheads for materials deposition and digital printing. Linda joined Dimatix (formerly Spectra) in 1985 after 10 years ink jet development with Xerox R&D and 7 years liquid display research at Texas Instruments. She has a number of technical publications and more than 15 US and foreign patents in the fields of ink jet technology and liquid crystal displays. She received her B.S.(1962), M.S.(1963) and Ph.D(1967) from the University of North Texas.